

1 May 1968

AD 718630
3679
Materiel Test Procedure 6-2-300
Electronic Proving Ground

U. S. ARMY TEST AND EVALUATION COMMAND
COMMODITY ENGINEERING TEST PROCEDURE

TOWERS AND MASTS

1. OBJECTIVE

The objective of this materiel test procedure (MTP) is to determine the engineering adequacy of towers and masts.

2. BACKGROUND

As verified by field comparison reports, antennas have increased service range of transmission (reception) when located at some site elevated above the surrounding terrain. In some circumstances, adequate range for communications needs can be achieved only by increased height of antennas. As higher and otherwise improved masts or tower structures are developed, there will be a continuing need for adequate tests. A general test outline is contained in this MTP. Specific requirements and specifications for such testing shall be derived from Qualitative Materiel Requirements (QMR's) or Small Development Requirements (SDR's) and formalized in Military Standards or Technical Characteristics (TS's) applicable to the specific test item.

3. REQUIRED EQUIPMENT

- a. Erection tools
- b. Torque wrenches to fit test item bolts
- c. Tension measurement spring scale
- d. Pneumatic gauge
- e. Hydraulic gauge

4. REFERENCES

- A. TECOM Reg. 385-2 18 Feb 63
- B. TECOM Reg. 385-6 24 Oct 62
- C. TECOM Reg. 385-7 18 Dec 62
- D. TECOM Reg. 705-1 16 Feb 65
- E. TECOM Reg. 705-2 28 Feb 66
- F. TECOM Reg. 705-4 19 Jun 64
- G. TECOM Reg. 705-11 24 Mar 65
- H. TECOM Test Directives as applicable
- I. TECOM Technical Requirements as applicable
- J. TM 11-5895-344 MAST AB-746/G 1965
- K. TM 11-5985-211 Tower AB-127/F4 1959
- L. MIL-STD 778 Maintainability Terms and Definitions
- M. AFSCM, 80-1, Part I, Maintainability 1964
- N. Handbook of Chemistry and Physics, The Chemical Rubber Co. 1964-65

5. SCOPE

5.1 SUMMARY

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This MTP presents engineering tests of towers and masts to determine operational characteristics.

a. Lift Mechanisms - The objective of this subtest is to determine the adequacy, convenience, and reliability of components and auxiliary hoist devices provided.

b. Locking Components - The objective of this subtest is to determine the engineering adequacy of bolts, shackles, assembly hardware, and holding clamps.

c. Guy Cables, Tension Devices, and Anchorage - The objective of this subtest is to determine the strength and utility of cable, attachment, and anchorage elements. Accuracy and utility of tension devices shall be determined.

d. Platforms, Braces, Struts, and Ladders - The objective of this subtest is to determine the strength, engineering adequacy, and compliance with specifications.

e. Instruction Manual - The objective of this subtest is to provide an engineering evaluation of the manual(s), clarity and usefulness.

5.2 LIMITATIONS

a. This MTP shall be applicable to the common characteristics of towers and masts. These two devices for elevated placement of equipment are essentially different in concept, design, and usage. The mast is smaller, lighter, and more easily collapsible and transportable. The tower may be considered movable but not mobile, but because of its greater weight and rigidity, useful where increased height and weight support are desired.

b. Testing in this MTP is limited to engineering tests. However, in the conduct of the tests, the procedures may be closely similar to service tests but under controlled conditions. It may be desirable to conduct combined engineering/service tests.

c. Criteria may be not available for all tests.

6. PROCEDURES

6.1 PREPARATION FOR TEST

a. Administrative support and test area(s) shall be listed and requested.

b. Test schedule and personnel requirements shall be tabulated.

c. Record forms shall be prepared in sufficient copies for the test.

d. Criteria shall be finalized.

e. Torque wrenches and tension test devices shall be calibrated.

f. Instruction manuals shall be reviewed and personnel briefed on test purpose and conduct.

g. The test item shall be checked for completeness, evidence of damage, and operation.

h. Test crew shall be given practice in operations, assembly, and disassembly.

i. Hydraulic systems shall be checked for leaks and adequate fluid.

6.2 TEST CONDUCT

6.2.1 Lift Mechanisms

6.2.1.1 Pneumatic System for Masts

- Connect the pump or air supply to a calibrated pressure gauge through a flow meter.
- Actuate the pump and measure the volume output per minute at atmospheric pressure.
- Actuate the pump with the output connected to the mast elevation system as shown in Figure 1.

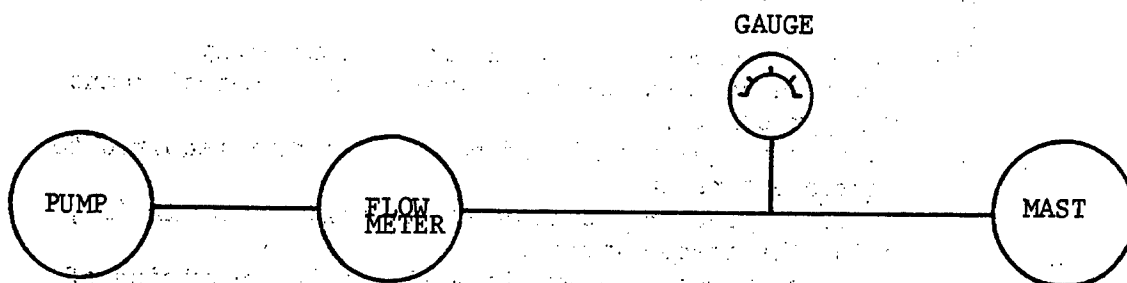


Figure 1. Setup for Pressure Measurement

6.2.1.2 Hydraulic System for Masts

- Connect the pump to a calibrated pressure gauge and to the elevation system.
- Actuate the pump, extending the mast to the maximum. Repeat with antenna load.
- Continue to actuate the pump until the gauge registers 210% of the second reading in b. Maintain this pressure for 15 minutes.

6.2.1.3 Mechanical System for Masts

- Extend the mast 10 times.
- Apply a spring scale to the winch handle at the beginning, near the end, and at least 4 times during the erection cycle.
- With the mast fully extended, apply 150% of the greatest force observed in b.

6.2.1.4 All System Types (Masts)

- Place the mast in a current of air (in a wind chamber when available) varied in 10 mph increments to 60 mph. At each wind speed, extend and retract the mast 10 times, measuring the effort required.
- When height prevents chamber test, perform the above in the open under various wind conditions. Measure the wind speed and try for several speeds, up to 60 mph, within time limits for the test completion.

6.2.1.5 Tower Hoist Devices

- a. Weigh adapter, counterweight, and antenna sections.
- b. Install hoist and load with a weight twice that of the largest found in a.
- c. Install support arm, when supplied, and load it as in b.

6.2.2 Locking Components

- a. This subtest shall include nut and bolt assembly elements, T-bars, swing clamps, shackle and bolt sets, and other elements of similar nature.
- b. Perform the test for each such element as follows:
 - (1) Place the element in its designated assembly and tighten with the issue wrench or by manual means as appropriate.
 - (2) Apply a torque wrench and note the effort required to increase tension.
 - (3) Increase pressure to 120% of the value found in (2), using the torque wrench.
 - (4) Testing of manual elements will require provision of an adapter to ensure torque wrench stability, convenience, and accuracy.
- c. Dissassemble each tested element and repeat a minimum of 10 times or as indicated by test directive or other applicable requirement. During and after each disassembly, examine threads and locking surfaces for galling of metal and signs of excessive friction.

6.2.3 Guys, Cables, Tension Devices, and Anchorage

- a. Apply measured tension to the tension elements in the laboratory.
- b. Vary the magnitude from zero to maximum design value.
- c. Apply tension to the guys to 120% the maximum measured in b.
- d. Apply tension to the cables (other than guy lines) to the specified maximum, to the maximum load determined in operation, or as specified in applicable military standards.
- e. Load the anchor plate(s) to 200% of actual load at each site where soil conditions and composition are materially different from other test sites.

6.2.4 Platforms, Braces, Struts, and Ladders

- a. Braces and struts are compression members used as single members to complete the truss design as tower erection proceeds. Upon occasion, such members may be required to withstand tension stresses.
- b. Single members shall be tested for tensile strength when attached to assembly fittings by placement in a tension measurement unit of a materiel test laboratory.

c. Material and cross-section measurements determine stress limits which may be found in handbooks such as reference N. Such limits, checked against military specifications, shall be the guide. The test item shall be tested to 50% of the limit so determined.

d. Determination of tensile force shall be made for the minimum shear plane where failure may be anticipated. This is expected to be at the bolt or hole.

e. Platforms and ladders shall be supported in their normal position at or near ground level and subjected to loads increasing to 500 pounds or until deformation is observed.

f. Ladders shall be tested step by step; but no more than 300 pounds shall be placed on a single step. A load of 200 to 300 pounds shall be placed on the first step, then the second step shall be loaded to make the total 500 pounds or until deformation is observed. This sequence will be repeated for each step.

6.2.5 Instruction Manual

a. The test item shall be unpacked, assembled, and erected as directed in the manual.

b. Each step in the directions shall be closely compared with the description in the manual.

c. Where difficulty is found or where the manual is inexact, an evaluation shall be made and recommendations provided, indicating engineering changes to improve the step sequence. Use of engineering terminology appropriate to the test item shall be evaluated.

6.3 TEST DATA

6.3.1 Lift Mechanisms

6.3.1.1 Pneumatic System for Masts

a. Record pump output rate in cubic feet per minute (cfm).

b. Record total pump output volume (cu ft) from rest to full mast extension.

c. Record pump pressure in pounds per square inch (psi).

d. Record excess pressure produced by continued pumping (120% in c.).

e. Record leaks and rate of loss of pressure (psi per minute).

6.3.1.2 Hydraulic System for Masts

a. Record hydraulic pressure (psi) with mast fully extended.

b. Record hydraulic pressure (psi) with antenna fully loaded and extended.

c. With pump operating, record pressure (psi) up to 120% of reading in b.

6.3.1.3 Mechanical System for Masts

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- a. Record the spring scale reading in pounds at each step with adapter and antenna attached.
- b. Record the highest reading taken
- c. Record abnormal effects, displacement of pulleys, or damage from application of the increased pressure.

6.3.1.4 All System Types (Masts)

- a. Record effort in pounds required for mast extension under various wind conditions by taking series of readings during erection at each wind speed (air pressure, hydraulic pressure, and manual power).
- b. Record tensions in pounds produced in guy cable as read on the tension devices, resulting from wind forces at each wind speed.

Record comparison readings with a calibrated spring scale.

6.3.1.5 Tower System

- a. Record weights in pounds
- b. Record force in pounds required to lift heaviest section.
- c. Record force in pounds to lift the double load.
- d. Record ability of support arm to hold the double load without deformation.

6.3.2 Locking Components

- a. This subtest is applicable in conjunction with (and as an addition to) observations made in the erection-dismantling cycles; this subtest is related to maintainability and to reliability.
- b. Record elements tested and wrench used for normal manual assembly.
- c. Record torque value in foot-pounds.
- d. Record result of application of 120% of the value in c.
- e. Record physical condition of threads, nuts, and turn bars after each operation cycle.

6.3.3 Guys, Cables, Tension Devices, and Anchorage

- a. Record tension in pounds.
- b. Record readings of tension device scale.
- c. Record tension on guys and evidence of damage, if any.
- d. Record test values in pounds for each cable.
- e. Record pressures applied in pounds per square inch and depth of depression at normal loading, then at increased loading.

6.3.4 Platforms, Braces, Struts, and Ladders

- a. Members tested for tensile strength shall be recorded by stock number. Opposite each shall be recorded the stress limit, the stress applied, and the effective cross section tested.

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Stress limit lbs per sq in	Cross section tested (in ²)	Stress applied pounds	Result
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b. Deviations of platforms from vertical and horizontal shall be recorded by amount versus applied load.

c. The ladder load variations shall be recorded by the ladder steps to which applied, e.g., 300 pounds on first step, 200 pounds on second step, 300 pounds on third step and so on. Deviations of the side rails shall be recorded at each change or weight.

6.3.5 Instruction Manual

a. Adaptability of the instruction manual is largely a function of the service test. It shall be tested in engineering tests, however, to determine areas of engineering lacks or possible changes to simplify use of the manual.

b. Records shall be made of every discrepancy in terminology, precautionary steps to improve safety, and ease of assembly.

c. The many cycles of assembly and disassembly can yield variations of method simplification which shall be recorded with comment on comparable manual paragraphs.

6.4 DATA REDUCTION AND PRESENTATION

6.4.1 Lift Mechanisms

6.4.1.1 Pneumatic System for Masts

a. From data taken during at least 10 cycles of extension and retraction determine pump output volume and pressure required.

b. Present a list of leaks and pressures at which they took place.

6.4.1.2 Hydraulic System for Masts

a. Compute average pressure, mast extended.

b. Compute average pressure, mast loaded.

c. Present a list of leaks and pressures at which observed.

6.4.1.3 Mechanical System for Masts

a. Compute the average forces

b. Present results as follows:

Average Force	Maximum Force	Effects noted at 150% maximum
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Stage 1

2

n

c. Proportional comparisons may be made directly from observed values. Forces applied to the lift cable may be determined by use of the following equation:

$$\text{Force on cable} = \text{Observed Force} \times \frac{R_c}{r_d}$$

Where: R_c = Length of crank

r_d = radius of drum

6.4.1.4 All System Types (Masts)

a. Compare variations in pressure (or forces) caused by mast extension under wind load.

b. Determine averages for each wind speed.

Pneumatic pressure
hydraulic pressure
or mechanical effort
at zero wind

Same at

10 mph

20 mph

30 mph

40 mph

50 mph

60 mph

1st order difference

variation with wind

c. Present graphically the effect of wind speed versus effort to extend the mast.

d. Compare tensile strength of lift cable with increased effort caused by wind.

e. Present the variation of all tension device readings at each wind speed.

f. Present the variation of each device from wind speed to wind speed.

	T	T	T	T	
	1	2	3	4	etc.

Wind speed

10 mph

20 mph

60 mph

T
1 etc. are the changes from zero wind

Average Change

6.4.1.5 Tower Hoist Device

- a. No reduction is necessary.
- b. Present values of weights applied and indicate suitability of the hoist and its supporting agency.

6.4.2 Locking Components

- a. Presentation shall consist of tabulation of parts tested, number of assembly-dissassembly actions, and ability of devices to hold supported elements without slippage.
- b. When slippage occurs, additional required motion of locking device shall be presented.

6.4.3 Guys, Cables, Tension Devices and Anchorage

Present relation between specification requirement, technical limit of strength, and the tensile test force applied.

<u>Device tested</u>	<u>Spec.</u>	<u>Tabular limit</u>	<u>Test force</u>
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6.4.4 Platforms, Braces, Struts, and Ladders

Present specified strengths versus loads applied for each component tested.

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<u>Item</u>	<u>Spec.</u>	<u>Applied load</u>
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6.4.5 Instruction Manual

Present deficiencies found in engineering applications of the manual. Specific changes, additions, and deletions shall be put in narrative form with explanation as necessary.